Request for Proposal
Derivation of Molybdenum Water Quality Criteria for Protection of Aquatic Life

RFP Release Date: March 9, 2007
Proposal Submission Date: April 13, 2007

Bureau of Water Quality Planning
901 S. Stewart Street, Suite 4001
Carson City, NV 89701

This Request for Proposal consists of (12) pages (including cover sheet)
and two (2) attachments

1. OVERVIEW OF PROJECT

The Nevada Division of Environmental Protection, Bureau of Water Quality Planning (NDEP-BWQP), is soliciting proposals to derive appropriate molybdenum water quality criteria. The criteria would be applicable either on a state-wide basis or on a basin-specific (regional) basis, and would provide protection for aquatic life beneficial uses found in Nevada surface waters.

The successful applicant selected will be required to sign a state contract and NDEP agency terms and conditions. The contract resulting from this Request for Proposal will commence upon approval by the State Board of Examiners (BOE).

2. SCOPE OF WORK

2.1 Introduction

2.1.1 Background

The Clean Water Act provides the authorization for States to adopt water quality standards that include beneficial uses and narrative or numeric criteria to protect the uses. During promulgation of water quality standards, States may pursue development of site-specific water quality criteria to support designated uses. Pursuant to Nevada Revised Statutes (NRS) 445A.520, water quality standards may be established which differ from standards based on recognized criteria if such variations are justified and appropriate.

The current State of Nevada (2006 NAC 445A.144) molybdenum water quality standard for protection of aquatic life beneficial use is 19 µg/l and was adopted based on recommendations contained in a report prepared by the California State Water Resources Control Board (1988) on the regulation of agricultural drainage to the San Joaquin River. The 19 µg/l standard was based on scientific literature from three studies (see Appendix A). The relevance and applicability of the molybdenum standard to Nevada surface waters has been frequently questioned. It is proposed to derive appropriate molybdenum aquatic life criteria based on a more thorough up to date compilation of molybdenum aquatic life toxicological studies. The derived criteria will be specific to and protective of the aquatic life species that occur in Nevada surface water bodies.

In December 2003, Shepherd Miller-MFG, Inc. prepared and submitted a report to NDEP on the derivation of protective beneficial use values for specific contaminants in the Humboldt River system. Protective acute and chronic molybdenum aquatic life criteria were proposed in this report.

The report's proposed criteria were derived from a more detailed set of toxicity test data on the effects of molybdenum to freshwater aquatic life than what was used in the 1988 California State Water Resources Control Board report. The sections of the Shepherd Miller-MFG, Inc. report pertaining to the molybdenum toxicity test data and the aquatic life protective beneficial use values derived for molybdenum are included in Appendix A for use in preparing a proposed work plan.

2.1.2 Objective

The State of Nevada, NDEP-BWQP is seeking a qualified candidate with expertise to derive appropriate and defensible molybdenum water quality criteria for protection of aquatic life beneficial uses in Nevada surface waters. The resulting criteria will be based on readily available and pertinent toxicity test records and results for molybdenum effects to aquatic life that have been published in the scientific literature and compiled in relevant databases. This project would likely not involve conducting any laboratory testing to develop molybdenum toxicity test data on site-specific resident aquatic life species.

The approach used to derive the molybdenum criteria must be based on methods and protocols that are accepted and/or used by the U.S. Environmental Protection Agency (EPA) for determining protective aquatic life criteria values.

2.2 Services Requested

For each component listed in Sections 2.2.1 to 2.2.6, applicants must submit a Work Plan which details how they propose to accomplish the tasks of each component. Timeframes outlined in this RFP are projections to meet NDEP-BWQP work plan schedule for regulation changes but it is recognized that other factors may change these projections.

2.2.1 *Component A – Data Collection, Review, and Assessment*

Review available scientific reports, journals, and databases to compile appropriate toxicity test data and results from studies conducted on the effect of molybdenum to aquatic life species that may be relevant to Nevada waters. Requirements outlined in EPA guidance documents will be used to determine whether the test data is suitable for deriving aquatic life criteria values. Additional toxicity test records which meet the requirements will be used to supplement the aquatic life toxicity data for molybdenum that was complied in the Shepherd Miller-MFG, Inc. report (December 2003).

Based on the toxicological data compiled, determine if adequate data exists to substantiate the existing molybdenum aquatic life standard or to support derivation of appropriate criteria consistent with EPA approved methodologies. Methods used to derive the molybdenum aquatic life criteria must be defensible. The conceptual approach that would be used to determine the criteria will be outlined.

This evaluation and recommendation will be made within 2 months from the project start date.

2.2.2 *Component B – Methodology Report*

Prepare a **Methodology Report** that summarizes the rationale and approach to be used in deriving the appropriate molybdenum criteria. This report should include a review of the existing molybdenum aquatic life standard, the assumptions to be used in deriving the appropriate criteria, and the procedures that will be used to determine criteria values. The sources of supporting data including how it will be used must be presented.

The **Methodology Report** will be submitted within 3 months from the project start date.

2.2.3 *Component C – Meeting with EPA-Region 9*

The **Methodology Report** will serve as the basis for a meeting with EPA to develop an understanding and concurrence, in principle, of the State of Nevada, NDEP-BWQP intent to derive state-wide or regional-specific molybdenum water quality criteria for the protection of aquatic life. The successful applicant will participate in this meeting and provide an overview of the rationale and approach to be used to determine the appropriate molybdenum criteria.

It is anticipated that this meeting would occur 1 month after the **Methodology Report** is submitted to NDEP-BWQP.

2.2.4 *Component D – Molybdenum Aquatic Life Criteria*

Derive appropriate aquatic life water quality criteria for molybdenum. The derivation of the criteria should take into account comments made by EPA and NDEP-BWQP on the assumptions and methodology outlined in the Methodology Report.

Proposed criteria will be submitted to NDEP-BWQP within 6 months after the project start date.

2.2.5 *Component E – Technical Report*

Prepare a **Draft Technical Report** that details the rationale, assumptions, and methodology followed in deriving the molybdenum water quality criteria for protection of aquatic life. Toxicity test data used in deriving the criteria must be included as supplemental information to the report.

The **Draft Technical Report** must be submitted to NDEP within 8 months from the project start date.

Prepare a **Final Technical Report** based on comments made by NDEP-BWQP on the draft report. The Final Technical Report will be used to either substantiate the existing molybdenum standard or to support and justify any possible regulatory changes to the molybdenum aquatic life standard.

The **Final Technical Report** will be submitted 10 months from the project start date.

2.2.6 *Component F – Technical Assistance*

Provide technical support to NDEP- BWQP for the following:

- Participate in Public Workshops to explain any proposed changes to the molybdenum aquatic life standard. It is anticipated that three workshops (Carson City, Elko, and Las Vegas) would be conducted to inform the public and regulated community about possible proposed changes to the water quality standards and to solicit comments from interested persons/parties.

- Participate as necessary in the State Environmental Commission (SEC) public hearing where NDEP-BWQP would formally present the derived molybdenum aquatic life standard for consideration and adoption as part of the State of Nevada water quality regulations.

- Assistance to address possible EPA review comments of the Final Technical Report and possible questions that may arise during consultation regarding any proposed molybdenum aquatic life standard(s) submitted for approval.

2.3 Deliverables

Required deliverables include:

- Quarterly Progress Reports for each component

- o Methodology Report
- o Draft Technical Report
- o Final Technical Report
- o Technical support to NDEP-BWQP

3. Submittal Instructions

3.1 Questions/Information

The Bureau of Water Quality Planning will accept questions and/or comments in writing, received either by mail, e-mail or facsimile, regarding this RFP as follows. Questions should be addressed to:

Nevada Division of Environmental Protection
Bureau of Water Quality Planning
Attn: Paul Comba
901 S. Stewart Street, Suite 4001
Carson City, Nevada 89701

or e-mailed to pcomba@ndep.nv.gov or faxed to (775) 687-5856.

Submitted questions and NDEP-BWQP responses will be made available to all interested parties online at http://ndep.nv.gov/.

3.2 RFP Timeline

TASK	*DATE/TIME*
Deadline for submitting questions	March 26, 2007
Questions submitted and responses available online at http://ndep.nv.gov/.	March 30, 2007
Deadline for submission of proposals	**April 13, 2007 @ 5:00 pm (Pacific Time Zone)**
Evaluation period	April 16, 2007 – April 27, 2007
Selection of successful proposal	May 4, 2007
Anticipated Project Start Date	Mid June 2007

NOTE: These dates represent a tentative schedule of events. The State reserves the right to modify these dates at any time, with appropriate notice to prospective vendors.

3.3 Proposals are to be submitted to the address below.

Paul Comba
Nevada Division of Environmental Protection
Bureau of Water Quality Planning
901 S. Stewart Street, Suite 4001
Carson City, Nevada 89701

3.4 Proposals are to be submitted as two (2) components: a **narrative/technical proposal** and a **cost proposal**. The technical and cost proposals may be submitted together.

3.5 Proposals must be received by **5:00 p.m. Pacific Daylight Time on April 13, 2007**. Proposals that do not arrive by this time and date **will not be accepted**. Proposals may be submitted any time prior to the above stated deadline. Facsimile or telephone proposals will **NOT** be considered.

3.6 Proposal must be presented in a format that corresponds to and references sections outlined within this RFP and in the same order. Responses to each section and subsection should be labeled so as to indicate which item is being addressed. Exceptions to this format will result in a lower evaluation.

3.7 Proposals should provide a straightforward, concise delineation of capabilities to satisfy the requirements of this RFP. Expensive bindings, colored displays, promotional materials, etc., are not necessary or desired. Emphasis should be concentrated on conformance and responsiveness to the RFP requirements, and on completeness and clarity of content.

4. Proposal Contents

4.1 Narrative/Technical Proposal

The narrative/technical proposals shall contain, as a minimum, the following sections:

A. Letter of Transmittal

B. Cover Page with the following information:

- Project Title
- Lead Agency - State the name of the entity that will be entering into the legal contract
- Primary Contact - Provide name, title, phone number, fax number, e-mail address, mailing address
- Anticipated Start and Completion Dates

C. Definition of the Problem: Indicate your understanding of the problem and the project objectives.

D. Project Approach: Provide a general description of rationale and approach to meet project objectives.

E. Work Plan and Methodology: Describe the major tasks to be performed to address each component of the scope of work, including methods, techniques, and protocols to be used. Provide timeline and deliverables.

F. Similar Project Experience: Describe recent and relevant experience in similar projects within the past five years.

G. Statement of No Conflict of Interest or Appearance Thereof (1 page maximum).

4.2 Cost Proposal

Note: Cost information must be submitted as a separate component

Please use the following matrix as a template for presenting the projected sub-total cost for each work plan component and the overall estimated Total Project Cost. Use additional sheets, if necessary.

Component-Deliverables	# of Personnel Hours Needed	Personnel Hourly Rate	Travel Costs	Operating Costs	Equipment/ Supplies	Other Costs (specify)	Sub-Total ($)
A. Data Collection, Review and Assessment							
B. Methodology Report							
C. Meeting with EPA-Region 9							
D. Molybdenum Aquatic Life Criteria							
E. Technical Report							
F. Technical Assistance							
Total Cost							**$**

For each component listed in the matrix above, list the position title, number of personnel hours needed, and the corresponding personnel hourly rate for the positions who will work on each task. For the above matrix, *personnel hourly rate = salary + fringe benefits + Section 4.2.3 costs*.

As explained below, fringe benefits and Section 4.2.3 costs would need to be itemized in the Example Contract Budget. Travel costs, operating costs, and equipment/supplies are explained in more detail below.

The cost proposal should contain three sections: the Cost Matrix, a Budget Summary and a Budget Detail. See Attachment A for examples of a Budget Summary and a Budget Detail. The project may or may not contain all of the expenditure categories listed in the examples. List only those categories relevant to the project budget. Provide as much detail as possible.

4.2.1 **Salaries.** Total salary expenses must be included in the Cost Proposal. In the Budget Detail under Salaries, list the position title and base salary rate for individuals who will work on the project. Base salary rates (excluding fringe benefits and/or indirect costs) shall not exceed a federal Executive Service Level 4 (U.S. Code) daily rate ($69.66 per hour).

4.2.2 **Fringe Benefits.** Fringe benefits are items such as health insurance, retirement and medical benefits. In the Budget Detail under Fringe Benefits, list the percentage of the base salary rate used to calculate the fringe benefits. If different fringe benefit rates apply to different personnel, the rates must be listed separately for each individual. Total fringe

benefits must be included in the Budget Summary as shown in the example.

4.2.3 **Administrative Costs/Overhead/IDC.** These costs are the costs of running the organization so that the project can be completed and may include telephones, rent, utilities for support staff, and postage. Total administrative/overhead costs must be included in the Budget Summary. These costs must be itemized in the Budget Detail. Indirect cost (IDC) charges are available only to entities that have a negotiated IDC rate with their cognizant agency.

4.2.4 **Travel.** Travel costs may not exceed the State approved rates. Travel costs include transportation, per diem, and lodging and cannot exceed State authorized rates, currently as follows:

- Vehicle mileage: 48.5 cents per mile.
- In-State Per Diem: $26.00 ($5.50 breakfast, $6.50 lunch, and $14.00 dinner)
- In-State Lodging: $58.00 per night
- Airfare: Actual cost
- Airport Parking: Actual cost

Travel costs should be itemized in the Cost Matrix and included as a Total Travel Cost in the Budget Summary. Vendors will provide Travel Costs during invoicing on State Travel Cost forms.

4.2.5 **Operating.** All operating costs must be itemized in the Cost Matrix and Budget Detail and may include costs for copying, printing, and supplies. Supplies and materials (consumables) must be itemized under a subcategory of Operating and may include things such as film, envelopes, signs and maps. In the Budget Summary, Total Operating costs should be listed as a line item amount.

4.2.6 **Subcontracts.** Total subcontract costs must be included in the Budget Summary. Subcontracts also must be itemized in the Cost Matrix and Budget Detail. Any subcontract must conform to the terms and conditions of the original contract with the NDEP. A separate contract budget must be submitted in the example format for each subcontract when the subcontract is executed. All conditions described above apply to any subcontract.

5. Proposal Evaluation and Award Process

5.1 Proposals will be evaluated based upon the following:

- Work Plan – Scope of Work, Component A to Component F;
- Demonstrated competence;
- Experience in performance of comparable projects;
- Reasonableness of cost;
- Expertise and availability of key personnel;
- Financial stability; and
- Conformance with the terms of this RFP

5.2 All applicants will be notified in writing whether they have been selected to complete this project.

5.3 Any contract resulting from this RFP shall not be effective unless and until approved by the Nevada Board of Examiners (NRS 284.173).

Attachment A

Example Budget

Example Contract Budget

[EXAMPLE]

Budget Summary

Category	Cost
Salaries	$4,500.00
Fringe Benefits	1,125.00
Administrative Costs *	281.25
Travel	100.00
Operating	1,500.00
Equipment	400.00
Subcontract **	12,000.00
Total	$19,906.25

* ***Indirect cost accepted only for agencies with negotiated rate.***

** ***The awarded vendor will ensure that the maximum salary rate (exclusive of fringe benefits and Section 4.2.3 costs) for any subcontractor does not exceed $69.66 per hour***.

[EXAMPLE]

Budget Detail

Salaries	Hourly Rate
Manager	25.00
Foreman	15.00
Administrative Assistant	12.00

Fringe Benefits

25% of Salaries

Administrative Costs (or IDC)

5% of Salaries plus Fringe
(Postage, Telephones and rent)

Travel	Rate
Per-Diem	$84.00/day (State approved rate)
Vehicle Mileage	$0.485/mile (State approved rate)
Airfare	Actual cost
Parking	Actual cost

NOTE: May not exceed the above State approved rates.

Operating	Rate
Copying (In-house)	$0.05/copy
Printing (Outside)	Actual cost
Supplies/Materials	Actual cost

Subcontract	Cost
(Subcontract Description)	

NOTE: Any subcontract must conform to the terms and conditions of the original contract with the State. A contract budget in this format must be submitted for each subcontract.

Appendix A

RFP
Supplemental Information

Interim Final

DEVELOPING PROTECTIVE VALUES FOR BENEFICIAL USES IN THE HUMBOLDT RIVER: BORON, FLUORIDE, MOLYBDENUM, AMMONIA, pH, AND TDS

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December 2003

3.4.1 Aquatic Life

As part of this review, information from the USEPA's AQUIRE database on molybdenum and its major compounds was obtained and reviewed. Additionally, the scientific literature was queried to obtain other available toxicological studies of molybdenum effects to aquatic life. Much of the data from these two sources overlapped. Data from the AQUIRE database were limited, with only 38 individual records for freshwater effects. Of these records, 21 provided information for chronic effects to different organisms, while 17 records provided information for acute effects. Table 3.11 presents a summary of test data by broad taxonomic categories.

Table 3.11 Ranges of evaluated concentrations of molybdenum to aquatic life

Organisms	Number of Data Records	Number of species represented	Minimum of range ug/L	Maximum of range ug/l
Fish	16	3	49	12,500,000
Invertebrates	17	1	360	> 430,000
Plants/algae	4	3	1	300,000
Microbes	1	1	1726	17,262

For the fish data, the reported concentrations that resulted in acute effects ranged from >50,000 ug/L for mortality in silverside minnows to 1,500,000 ug/L for mortality in rainbow trout. Considering only the 96-hour LC50 data, the acute effects concentrations ranged from 67,800 ug/L for fathead minnows to 1,320,000 ug/L for rainbow trout. Chronic test data concentrations ranged from 49 ug/L for rainbow trout mortality in 7-month exposures, to 12,500,000 ug/L for rainbow trout in a 6-month exposure. However, only one data record (730 ug/L, LC50) is available for the typical 28-day exposure period for fertilized rainbow trout eggs, as an early life stage fish test.

Invertebrate data records were only available for the waterflea, *Daphnia magna*. Acute invertebrate test data were represented by six test records, and concentrations ranged from 3,200 ug/L in 96-hour exposures to >430,000 ug/L in 48-hour exposures. Two 96-hour LC50 values were available, 3,200 ug/L and 38,200 ug/L. Chronic test data were represented by 11 records, with concentrations ranging from 360 ug/L for zero mortality in a 28-day test, to 8,680 ug/L for no reproductive response in a 28-day exposure. Of note, was the 28-day LC50 for daphnid survival from Kimball (1978), which was 930 ug/L. From this testing, the 28-day NOEC and LOEC for reproduction were 670 ug/L and 1,150 ug/L, respectively.

No acute plant or algal data were available. Chronic plant and algal data were represented by four records that ranged from 1 ug/L for green algae in 3- to 23-day exposures to 300,000 ug/L for blue-green algae in 20- to 50-day exposures.

Only one microbe record was available in the available scientific literature. Unfortunately this record could not be classified as to acute or chronic test regimes due to insufficient information.

Due to the limited amount of data present in the AQUIRE database, additional toxicity studies were reviewed for effects information that might not have been included in the database. Applicable data located in this review were included in the criteria table provided in Section 4.3.1. A few studies were located that derived protective values. These studies are discussed below.

The California State Water Resources Control Board (CSWRCB 1988) provided a standard of 19 ug/L, based on scientific literature from three studies. The 19 ug/L standard was derived by taking the log mean of 'background' molybdenum concentration (0.68 ug/L) and an effect level of 519 ug/L. The effect level was calculated by taking the log mean of three reported long-term adverse effect levels from the literature: a 120 ug/L LC10 for rainbow trout in a 28-day exposure, a 960 ug/L LC50 for narrow-mouthed toads embryos/larvae in a 7-day exposure, and a 1150 ug/L reproductive effects value for daphnids in a 28-day exposure.

Suter and Tsao (1996) derived Tier II acute and chronic values for molybdenum, however the values were based on extremely limited data. Two daphnid acute and one chronic test were used together with a single fathead minnow test. The derived acute Tier II value was 7950 ug/L and the chronic value was 370 ug/L.

The review of the Ontario Ministry Environment's (OME 1998) criteria document for molybdenum provided some additional sources of data that were not present in AQUIRE. Where appropriate, these data are included in the derivation table for molybdenum. The interim water quality objective for molybdenum in Ontario is 40 ug/L. This value was derived by taking the lowest measured adverse effect value of 730 ug/L, for embryo/larval rainbow trout, and dividing by an uncertainty factor of 16.

The Province of British Columbia (Swain 1986) derived a water quality criteria for molybdenum based on a lowest 96 h EC50 for fathead minnows of 42,000 ug/L. Application factors applied to this value of 0.02 and 0.05 resulted in a 30-day not-to-exceed value of 1000 ug/L (chronic) and maximum value of 2000 ug/L (acute).

4.4 Molybdenum

Proposed protective values for molybdenum concentrations in water are provided in the subsequent sections. Values are developed for protection of aquatic life, for domestic water supply, for livestock water use, and for irrigation.

4.4.1 Aquatic Life

As with boron, the GLWQI approach was utilized to estimate Tier II acute and chronic criteria for molybdenum. Acute test data that met the inclusion criteria specified in the GLWQI (USEPA 1995) are listed in Table 4.7. These values were assembled and used to derive Tier II values for molybdenum, which are shown in Table 4.8. Using this approach, seven SMAVs were derived, which included three salmonid species, two warmer water fish species, one daphnid, and one isopod. Five of the eight taxa categories were satisfied allowing for use of 6.1 as the safety factor.

The most sensitive GMAV was for daphnids (206,719 ug/L), while the least sensitive GMAV was for trout 1,448,957 ug/L. Using the most sensitive GMAV and a safety factor of 6.1 the SAV was derived and equaled 33,888 ug/L. Dividing by two gives an SMC acute value of 16,944 ug/L. The Tier II ACR was derived from two values of 18 and an ACR of 234 from Kimball's (1978) studies to produce a final Tier II ACR of 42.3. Dividing the SAV by the ACR a Tier II SCV was derived equaling 800 ug/L.

In comparison, the MDEQ (2003) Tier II acute and chronic values are 14,000 ug/L and 800 ug/L. This approach included slightly more data than MDEQ's, as well as the ACR from Kimball's work. Had this ACR not been included, the final chronic value would have equaled 1600 ug/L. However, after reviewing the data from which this ACR was derived, there was no convincing evidence to suggest that it be excluded.

The GLWQI approach derives a chronic value that falls within the range of protective values described for molybdenum in Section 3.4.1. Although the Tier II values are based on a small amount of data, the most sensitive criterion (e.g., chronic value) does not stand out from previously derived values. From the studies reviewed, there is no evidence to suggest water hardness affects toxicity. However, the large range of effects data for similar species and the many forms of delivering soluble molybdenum to the test chambers may indicate toxicity is contingent on the valence state of molybdenum. While the aquatic life PBUV for molybdenum is based on the approach described above, it is also recommended that the value

Table 4.7 Molybdenum data used to derive Tier II acute and chronic criteria

Scientific Name	Common Name	Molybdenum (oxides) tested	End-point	Effect	Duration	Conc. (mg/L)	Hardness as mg/L $CaCO_3$	Reference
Oncorhynchus mykiss	Rainbow trout	molybdenum	LC50	MOR	96 hour	800		Goettl et al 1976
Oncorhynchus mykiss	Rainbow trout	molybdenum	LC50	MOR	96 hour	1320		Goettl et al 1976
Oncorhynchus mykiss	Rainbow trout		LC50	MOR	96 hour	6790	154	Bentley and Macek 1973 unpublished
Oncorhynchus mykiss	Rainbow trout		LC50	MOR	96 hour	7340	35	Bentley and Macek 1973 unpublished
Oncorhynchus mykiss	Rainbow trout		LC50	MOR	96 hour	4950	290	Bentley and Macek 1973 unpublished
Oncorhynchus kisutch	Coho salmon		LC50	MOR	96 hour	>1000	42	Hamilton and Buhl 1990
Oncorhynchus tshawytscha	Chinook Salmon		LC50	MOR	96 hour	>1000	42	Hamilton and Buhl 1990
Pimephales promelas	Fathead minnow		LC50	MOR	96 hour	7630	35	Bentley and Macek 1973 unpublished
Pimephales promelas	Fathead minnow		LC50	MOR	96 hour	70	20	Tarzwell and Henderson 1960
Pimephales promelas	Fathead minnow		LC50	MOR	96 hour	370	400	Tarzwell and Henderson 1960
Pimephales promelas	Fathead minnow	moly trioxide	LC50	MOR	96 hour	678		Kimball 1978
Pimephales promelas	Fathead minnow	moly trioxide	LC50	MOR	96 hour	577		Kimball 1978
Lepomis macrochirus	Bluegill	sodium molybdate	LC50	MOR	96 hour	6790	35	Bentley and Macek 1973 unpublished
Lepomis macrochirus	Bluegill	sodium molybdate	LC50	MOR	96 hour	1320		Easterday and Miller 1963
Lepomis macrochirus	Bluegill	amm. dimolybdate	LC50	MOR	96 hour	157	35	Bentley 1975
Lepomis macrochirus	Bluegill	molybdic trioxide	LC50	MOR	96 hour	86.6	35	Bentley 1975
Crangonyx pseudogracilis	Isopod		LC50	MOR	96 hour	2650		Martin and Holdich (1986)
Daphnia magna	daphnia	moly trioxide	LC50	MOR	48 hour	203.2		Kimball 1978
Daphnia magna	daphnia	moly trioxide	LC50	MOR	48 hour	210.3		Kimball 1978
Daphnia magna	daphnia		EC50	IMM	48 hour	3220		Bentley and Macek 1973 unpublished
Gammarus fasciatus	scud		EC50	IMM	48 hour	3940	119.4	Bentley and Macek 1973 unpublished

Table 4.8 Tier II calculations for molybdenum

Tier II Calculations		Conc. (mg/L)
FAV =	Lowest GMAV/acute factor (6.1)	33.89
AMV =	FAV/2	16.94
ACR =	Daphnia magna	234.00
	Default	18.00
	Default	18.00
Tier II ACR =		42.32
Tier II FCV =	Tier II FAV/ Tier II ACR	0.80

Swain (1986) provided a good review of McConnell (1976), which we were unable to obtain. The review indicates that long term toxicity studies of molybdenum exposures to rainbow trout were conducted. The review cites the following from McConnell (1976): "after one year of exposure no significant biological differences were noted in mortality, growth or hematocrits for fish exposed to molybdenum concentrations as high as 17 mg/L." This test regime used low hardness water ranging from 14 to 32 mg/L and was started with eyed eggs and extended through fingerling development of the trout.

Michigan's DEQ (MDEQ 2003) derived molybdenum criteria using the GLWQI approach (USEPA 1995). Acute test data used in the derivation included effects data for daphnids, isopod, fathead minnow, bluegill, and rainbow trout. GMAVs showed rainbow trout to be the most sensitive species (GMAV = 88,318 ug/L) and the isopod to be the least sensitive species (GMAV = 2,650,000 ug/L). The MDEQ (MDEQ 2003) derived an acute Tier II value of 14,000 ug/L and a chronic Tier II value of 800 ug/L.

The chronic protective levels derived for molybdenum in the reviewed reports range from 19 ug/L to 1000 ug/L. Empirically derived long-term testing with trout indicated no effects at 17,000 ug/L. Among other factors, the large range of protective concentrations may be due in part to a small amount of toxicity testing data that utilized various salts of molybdenum and varying test conditions (such as pH). These various salts and test conditions may yield molybdenum valence states that are more or less toxic than other molybdenum species. While it is not clear from the data, metal speciation for molybdenum may play an important role in toxicity to aquatic life, much like arsenic and chromium, where criteria are derived based on specific species of these metals.

Molybdenum

Scientific Name	Common Name	Life Stage Tested	Taxa group	Chemical Name	Endpoint	Effect	Test Duration	Duration Units	Exposure type	Exposure Type	Concentration Flag	Concentration Mean (ug/L)	Hardness Mean (mg/L) as CaCO3	Author	Year
Basilichthys australis	Silverside	NR	fish	Molybdenum	LD50	MOR	96	H	acute	S	>	50000		Trucco et al.	1991
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	Fertilization through 4 days	fish	Molybdenum	LC50	MOR	28	D	chronic	R		730	104	Birge et al.	1979
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	20 MM	fish	Molybdenum	LC50	MOR	96	H	acute	S		800000	25	Goettl et al.	1976
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	55 MM	fish	Molybdenum	LC50	MOR	96	H	acute	S		1320000	25	Goettl et al.	1976
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	20 MM	fish	Molybdenum	LOEC	MOR	96	H	acute	S		500000	25	Goettl et al.	1976
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	55 MM	fish	Molybdenum	LOEC	MOR	96	H	acute	S		1000000	25	Goettl et al.	1976
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	EYED EGGS	fish	Molybdenum	NR	MOR	7	MO	chronic	NR		49-17200	25.6	Goettl and Davies	1975
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	EGG	fish	Molybdenum	NR-ZERO	MOR	18	MO	chronic	F		50-18500	30	Goettl et al.	1976
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	NR	fish	Molybdenum	NR	ACC	42-723	D	chronic	NR		50-18430		Goettl and Davies	1977
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	NR	fish	Molybdenum	NR	HIS	96	H	acute	F		1500000		Goettl et al.	1976
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	NR	fish	Molybdenum	NR	GRO	6	MO	chronic	D		150000-12500000		Goettl et al.	1976
Oncorhynchus mykiss	Rainbow trout, Donaldson trout	EYED EGGS	fish	Molybdenum	NR	DVP	7	MO	chronic	NR		49-17200	25.6	Goettl and Davies	1975
Pimephales promelas	Fathead minnow	8-10 MM TL	fish	Molybdenum trioxide (MoO3)	LC50	MOR	96	H	acute	S		67800	HARD	Kimball	1978
Pimephales promelas	Fathead minnow	8-10 MM TL	fish	Molybdenum trioxide (MoO3)	LC50	MOR	96	H	acute	S		577000	HARD	Kimball	1978
Pimephales promelas	Fathead minnow	NR	fish	Molybdenum trioxide (MoO3)	LC50*	MOR	96	H	acute	S		70000	20	Tarzwell and Henderson	1960
Pimephales promelas	Fathead minnow	NR	fish	Molybdenum trioxide (MoO3)	LC50*	MOR	96	H	acute	S		370000	400	Tarzwell and Henderson	1960
Daphnia magna	Water flea	NEONATE, 12 H	invert	Molybdenum trioxide (MoO3)	LC50	MOR	48	H	acute	S	>	430000	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE, 12 H	invert	Molybdenum trioxide (MoO3)	LC50	MOR	48	H	acute	S		203200	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE, 12 H	invert	Molybdenum trioxide (MoO3)	LC50	MOR	96	H	acute	S		3200	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE-ADULT	invert	Molybdenum trioxide (MoO3)	LC50	MOR	28	D	chronic	R		930	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE, 12 H	invert	Molybdenum trioxide (MoO3)	LC50	MOR	48	H	acute	S	>	430000	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE, 12 H	invert	Molybdenum trioxide (MoO3)	LC50	MOR	48	H	acute	S		210000	HARD	Kimball	1978

Molybdenum (Continued)

Scientific Name	Common Name	Life Stage Tested	Taxa group	Chemical Name	Endpoint	Effect	Test Duration	Duration Units	Exposure type	Exposure Type	Concentration Flag	Concentration Mean (ug/L)	Hardness Mean (mg/L) as CaCO3	Author	Year
Daphnia magna	Water flea	NEONATE, 12 H	invert	Molybdenum trioxide (MoO3)	LC50	MOR	96	H	acute	S		35800	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE-ADULT	invert	Molybdenum trioxide (MoO3)	LOEC	REP	28	D	chronic	R		1150	HARD	Kimball	1978
Daphnia magna	Water flea	ADULT, 10 D	invert	Molybdenum trioxide (MoO3)	LOEC	REP	28	D	chronic	R		4500	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE-ADULT	invert	Molybdenum trioxide (MoO3)	MATC	REP	28	D	chronic	R		880	HARD	Kimball	1978
Daphnia magna	Water flea	ADULT, 10 D	invert	Molybdenum trioxide (MoO3)	MATC	REP	28	D	chronic	R		3100	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE-ADULT	invert	Molybdenum trioxide (MoO3)	NOEC	REP	28	D	chronic	R		670	HARD	Kimball	1978
Daphnia magna	Water flea	ADULT, 10 D	invert	Molybdenum trioxide (MoO3)	NOEC	REP	28	D	chronic	R		2200	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE-ADULT	invert	Molybdenum trioxide (MoO3)	NR	REP	28	D	chronic	R		360-8580	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE-ADULT	invert	Molybdenum trioxide (MoO3)	NR-LETH	MOR	28	D	chronic	R		2190	HARD	Kimball	1978
Daphnia magna	Water flea	NEONATE-ADULT	invert	Molybdenum trioxide (MoO3)	NR-ZERO	MOR	28	D	chronic	R		360	HARD	Kimball	1978
Daphnia magna	Water flea	ADULT, 10 D	invert	Molybdenum trioxide (MoO3)	NR-ZERO	MOR	7	D	chronic	R		800	HARD	Kimball	1978
Tetrahymena pyriformis	Ciliate	NR	other	Molybdenum	NR	POP	NR	NR	NR	NR		1726-17262		Stearns et al.	1978
Anabaena cylindrica	Blue-green algae	LOG GRO PHASE	plant	Molybdenum dioxide	NR	PHY	5-10	D	chronic	NR		5-150		Jacobs and Lind	1977
Cylindrospermum	Blue-green algae	CYLINDROSPERMUM MACHAILOWSKOENSE	plant	Molybdenum	NR	CEL	12-20	D	chronic	NR		1-300000		Goryunova and Maksudov	1970
Nostoc linckia	Blue-green algae	NOSTOC LINCKIA CALICOLA	plant	Molybdenum	NR	CEL	23-50	D	chronic	NR		1-300000		Goryunova and Maksudov	1970
Nostoc linckia	Blue-green algae	NOSTOC LINCKIA MUSCORUM	plant	Molybdenum	NR	CEL	10-22	D	chronic	NR		1-300000		Goryunova and Maksudov	1970

Notes: NR = not reported; D= Days; H = hours
Effects codes and other information associated with effects endpoints can be downloaded from the ECOTOX website at http://www.epa.gov/ecotox

Water Quality
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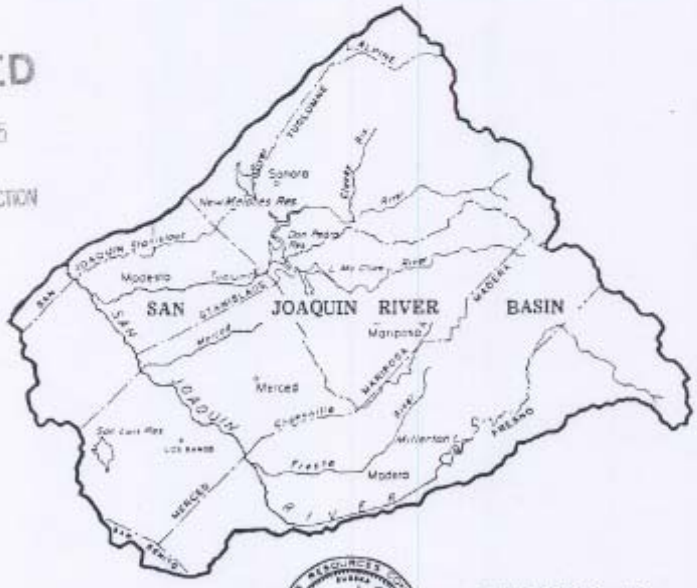
RCB ORDER NO. W.Q. 85-1
TECHNICAL COMMITTEE REPORT

REGULATION OF AGRICULTURAL DRAINAGE TO THE SAN JOAQUIN RIVER



APPENDIX D
Water Quality Criteria
Revised March 1988

STATE WATER RESOURCES CONTROL BOARD

Data points used:

0.96	mg/L	(rainbow trout)
1.1	mg/L	(Daphnia magna)
1.42	mg/L	(narrow-mouthed toad)

Adverse Effects Level (log mean of 3 values): 1.14 mg/L

Ambient background Concentration: .02 mg/L

Criterion: 0.15 mg/L (150 ug/L) (log mean of 1.14 mg/L and .02 mg/L)

4. Molybdenum (Mo)

Molybdenum is not an EPA Priority Pollutant, and no National Ambient Water Quality Criteria have been developed. Aquatic toxicity data for molybdenum are sparse. Only seven short term (96 hours or less) data points are available in the published literature, ranging upward from 70 mg/L. The lowest of these falls just above the range of reported long term effects, and is included in Table II-6.

Data from long term ("chronic") tests (greater than 96 hours) or on early life history stages are even less abundant. Only five available references provide data on long term effects, and many of these results are not

directly comparable since different endpoints are reported. One reference reports a no observable effect concentration (NOEC), which was the highest test concentration. The remaining data are from a series of papers by the same senior author (Birge). These papers report LC_{50} and LC_{1} levels for 7-28 day tests of several species and include one LC_{10} for one of these species. Since a LC_{50} is not a sensitive estimate of long term toxicity and a calculated LC_{1} near the lower limits of the test concentrations is not a very accurate estimate of a no effect level, these data are difficult to interpret. This is compounded by the lack of any other results of similar tests by other researchers. The LC_{50} and LC_{10} results have been included in Table II-6.

The three data points from Table II-6 representing long term adverse effects on the most sensitive species are: 0.12 mg/L (rainbow trout), and 0.96 mg/L (narrow-mouthed toad) and 1.15 mg/L (Daphnia magna). The LC_{10} for rainbow trout is a reasonable estimate of a significant effect level. However, lethality is not a sensitive endpoint for a long term test. The log mean of these three values is 510 ug/L which becomes the estimate of the adverse effects level. The recommended criterion

TABLE II-6
FRESHWATER ADVERSE EFFECTS FROM MOLYBDENUM

Species	Molybdenum (ppm)	Effect	Duration	Reference
Rainbow trout (embryo/larvae)	0.12/0.79	LC_{10}/LC_{50}	28 days	Birge et al., 1980
Rainbow trout (embryo/larvae)	0.73	LC_{50}	28 days	Birge, 1978; Birge et al., 1979
Narrow-mouthed toad (embryo/larvae)	0.96	LC_{50}	7 days	Birge, 1978
Daphnia magna	1.15	Reprod.	28 days	Kimball (MS)
Rainbow trout (eyed-eggs)	17.0	NOEC*	1 year	McConnell, 1977
Goldfish (embryo/larvae)	60.0	LC_{50}	7 days	Birge, 1978
Fathead minnow	70.0	LC_{50}	96 hours	Tarzwell and Henderson, 1976

*Highest Test Concentration

for molybdenum is calculated as the log mean of 510 ug/L (the adverse effects level) and 0.68 ug/L (the ambient background level), which gives 19 ug/L. The background level used is the average national surface water concentration reported by Hem (1970). The criterion value of 19 ug/L exceeds the agricultural irrigation water criterion (10 ug/L) in the San Joaquin Valley.

The lack of an adequate data base for molybdenum makes it impossible at this time to select acceptable data

points from sensitive bioassay tests. The preponderance of results from tests with lethal endpoints also reduces the reliability of the calculated criterion value. In this case it is questionable whether the data are sufficient to justify attempting to derive a criterion. The criterion value calculated should be considered a preliminary criterion subject to revision as new data become available. Priority should be given to developing data from long term, early life stage tests of sensitive resident species using non-lethal endpoints. It is expected that such data will result in a lowered criterion.

Summary of criterion calculation:

Data points used:

120	ug/L	(rainbow trout)
960	ug/L	(narrow-mouthed toad)
1150	ug/L	(Daphnia magna)

Adverse effects level (log mean of 3 values): 510 ug/L

Ambient background concentration: 0.68 ug/L

Criterion: 19 ug/L (log mean of 0.68 ug/L and 510 ug/L)